IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Heidi Cao et al.
Serial No.: 10/686,031
Filed : October 14, 2003
Title : PHOTORESISTS WITH REDUCED OUTGASSING FOR EXTREME ULTRAVIOLET LITHOGRAPHY

Art Unit : 1752
Examiner : Amanda C. Walke
Assignee : Intel Corporation

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Commissioner for Patents
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BRIEF ON APPEAL

Applicant hereby files this Brief on Appeal to perfect the Notice of Appeal filed November 28, 2006.

(1) Real Party in Interest

This case is assigned of record to Intel Corporation.

(2) Related Appeals and Interferences

There are no known related appeals and/or interferences.

(3) Status of Claims

Claims 1-35 are pending. Claims 1, 21, 25, and 33-35 are in independent form. Claims 1-9, 11, and 13-33 stand rejected. Claims 10 and 12 are objected to as depending from a rejected independent claim but otherwise allowable. Claims 34 and 35 are allowed. Hence, only the rejections of claims 1-9, 11 and 13-33 are appealed herein.

(4) Status of Amendments

All claim amendments have been entered.

(5) Summary of Claimed Subject Matter

Lithography uses light to transfer a pattern from a reticle to a photoresist. *See, e.g.*, *Specification*, para. [0001], line 4-6. The light can cause a solubility change in the exposed areas of the photoresist and certain areas can be selectively removed. *Id.*, para. [0001], line 6-10; para. [0012], line 3-12. The solubility change can be caused by a deprotection reaction in which a protecting group is cleaved from the photoresist during radiation exposure and baking. *Id.*, para. [0016]-[0017].

Lithographic patterning can be performed in a vacuum environment. *Id.*, para. [0019], line 6-7. Protecting groups and other species generated during a solubility change can outgas. *Id.*, para. [0018]. Outgassed molecules may contaminate and damage optics in an EUV lithography tool. *Id.*, para. [0021].

The present inventors have developed photoresists which reduce or eliminate outgassing. In particular, volatile species need not be generated by a deprotection reaction. *Id.*, para. [0023]. However, solubility changes can still be obtained. *Id.*, para. [0025].

CLAIM 1

Claim 1 relates to a photoresist (*Id.*, para. [0022], line 1-2) that includes:

a polymer backbone (*Id.*, para. [0022], line 4);

a lactone bonded to the polymer backbone (*Id.*, para. [0022], line 4-6; para. [0023], line 4-6), the lactone being reactable under semiconductor processing conditions and in the presence of an acid (*Id.*, para. [0025]) to undergo a ring-opening reaction and form an open ring structure (*Id.*, para. [0027]) to switch a solubility of the photoresist in a developer (*Id.*, para. [0028]) without generating an organic species that can outgas in a vacuum environment (*Id.*, para. [0025]-[0028]); and

a side chain bonded to the polymer backbone (*Id.*, para. [0022], line 4-6), the side chain comprising a styrene ring (*Id.*, para. [0022], line 6-8).

CLAIM 21

Claim 21 relates to a method that includes:

forming a photoresist having a polymer backbone (*Id.*, para. [0022], line 4) and a lactone bonded to the polymer backbone *Id.*, para. [0022], line 4-6; para. [0023], line 4-6); and

switching the solubility of the photoresist in a developer (*Id.*, para. [0028]) by exposing the lactone under vacuum (*Id.*, para. [0013]), thereby causing the lactone to undergo a ring opening reaction upon exposure to an acid catalyst without molecules outgassing from the photoresist (*Id.*, para. [0025]-[0028]),

wherein the lactone includes a tertiary carbon bonded to the lactone carbonyl oxygen (*Id.*, para. [0024]; FIG. 5A).

CLAIM 25

Claim 25 relates to a method that includes:

radiating an area of a chemically amplified photoresist in a vacuum environment to generate an acid within the photoresist *Id.*, para. [0012], line 3-12; para. [0026], line 2-3), and

catalyzing a ring-opening reaction in the photoresist (*Id.*, para. [0027]), the ring-opening reaction sufficing to switch the solubility of the photoresist in a developer (*Id.*, para. [0028]) without the generation of molecules that outgas from the photoresist in the vacuum environment (*Id.*, para. [0025]-[0028]).

CLAIM 33

Claim 33 relates to a photoresist that includes:

a polymer backbone (*Id.*, para. [0022], line 4);

a lactone fused to the polymer backbone (*Id.*, para. [0022], line 4-6; para. [0023], line 4-6), the lactone comprising a tertiary carbon bonded to the lactone carbonyl oxygen (*Id.*, para. [0024]; FIG. 5A); and

a styrene ring side chain bonded to the polymer backbone (*Id.*, para. [0022], line 4-8),

wherein sufficient lactone is fused to the polymer backbone so that a ring-opening reaction of the lactone to form an open ring structure suffices to switch a solubility of the photoresist in a developer (*Id.*, para. [0025]-[0028]).

CLAIM 34

Claim 34 relates to a photoresist comprising:

a lactone bonded to a polymer backbone (*Id.*, para. [0022], line 4-6; para. [0023], line 4-6), the lactone being reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure without generating an organic species that can outgas in a vacuum environment (*Id.*, para. [0025]-[0028]), the lactone having a first group comprising nitrogen dioxide attached to the carbon bonded to the lactone carbonyl oxygen (Id., para. [0024], line 4-5).

CLAIM 35

Claim 35 relates to a photoresist comprising:

a lactone bonded to a polymer backbone (*Id.*, para. [0022], line 4-6; para. [0023], line 4-6), the lactone being reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure without generating an organic species that can outgas in a vacuum environment (*Id.*, para. [0025]-[0028]), the lactone having a first group comprising $-CF_3$ attached to the carbon bonded to the lactone carbonyl oxygen (*Id.*, para. [0024], line 4-5).

(6) Grounds of Rejection to be Reviewed on Appeal

The following grounds of rejection are outstanding:

-claims 21-24 and 32 stand rejected under 35 U.S.C. § 102(b) as anticipated by Japanese Patent Publication No. 2002-082441 by Yoon et al. (hereinafter "Yoon"); and

-claims 1-9, 11, 13-18, 20, 25-31 and 33 stand rejected under 35 U.S.C § 103(a) as obvious over Yoon and U.S. Patent No. 6,680,157 to Fednyshyn (hereinafter "Fednyshyn").

As set forth in the following concise statements, the following grounds for rejection are presented for review:

I. The rejection of independent claim 21 under 35 U.S.C. § 102(b) as anticipated by Yoon.

II. The rejection of independent claim 25 under 35 U.S.C § 102(e) as obvious over Yoon and Fednyshyn.

III. The rejection of independent claim 33 under 35 U.S.C. § 103(a) as obvious over Yoon and Fednyshyn.

IV. The rejection of independent claim 1 under 35 U.S.C. § 103(a) as obvious over Yoon and Fednyshyn.

The other rejections are not presented for review on appeal at this time. Rather, the dependent claims are believed to be allowable for at least the same reasons as their parent claims.

(7) Argument

The organization of the arguments presented hereinafter follows the grounds for rejection to reviewed on appeal set forth above. In particular, separate boldfaced and underlined headings for each of these grounds presented for review follow.

I. The rejection of independent claim 21 under 35 U.S.C. § 102(b) as anticipated by Yoon.

Claim 21 relates to a method that includes forming a photoresist having a polymer backbone and a lactone bonded to the polymer backbone, and switching the solubility of the photoresist in a developer by exposing the lactone to an acid catalyst under vacuum, thereby causing the lactone to undergo a ring opening reaction upon exposure to the acid catalyst without molecules outgassing from the photoresist. The lactone includes a tertiary carbon bonded to the lactone carbonyl oxygen.

Yoon neither describes nor suggests switching the solubility of the photoresist in a developer by exposing the lactone to an acid catalyst under vacuum, thereby causing the lactone to undergo a ring opening reaction upon exposure to the acid catalyst without molecules outgassing from the photoresist, as recited in claim 21.

In this regard, Yoon describes a number of different resists that include annular lactones. *See, e.g., Yoon*, para. [0016], [0042], [0081]. Some of these annular lactones have a tertiary carbon bonded to the lactone carbonyl oxygen. *See, e.g., Yoon*, para. [0081], [0143], [0150].

To the best of applicant's understanding, none of these annular lactones undergo a ring opening reaction upon exposure to an acid catalyst and thereby switch the solubility of the photoresist, as recited. Instead, Yoon's photoresists appear to achieve the necessary solubility switching by undergoing cleavage of side chains. Indeed, for all of Yoon's annular lactones that have a tertiary carbon and for which a complete structure is provided, cleavable side chains are *always* present. *See Yoon*, para. [0143], [0150] (illustrating that a cleavable R4 group of 2-methyl-adamanthyl is present).

Please note that such cleavable side chains constitute relatively large percentages of Yoon's resists that include annular lactones having a tertiary carbon bonded to the lactone carbonyl oxygen. For example, in Formula 65, Yoon denotes moles of annular lactone having the claimed tertiary carbon as "k" and moles constituents from acrylate/methacrylate as "p." *See Yoon*, para. [0143]. The ratio of k/(k+p) is understood to be between 0.3 and 0.8. *See Yoon*, para. [0054]. The moles of the various comonomers is similarly denoted in Formula 66.

Applicant respectfully submits that such side chains are at least a significant part of the mechanism by which Yoon's photoresists achieve the necessary solubility switching. Moreover, such side chains will generally generate volatile organic species upon exposure to acid. In this regard, attention is respectfully directed to FIG. 3B of the present application and the written description thereof. There is no indication that Yoon can achieve the necessary solubility switching absent these side chains.

Since Yoon's annular lactones that have a tertiary carbon are all understood to achieve the necessary solubility switching, at least in part, using side chains and to outgas upon exposure to acid, claim 21 is not anticipated by Yoon. Yoon neither describes nor suggests switching the solubility of the photoresist in a developer by exposing the lactone to an acid catalyst under vacuum, thereby causing the lactone to undergo a ring opening reaction upon exposure to the acid catalyst without molecules outgassing from the photoresist, as recited in claim 21.

This was pointed out in the response filed May 30, 2006. In response, the Office action mailed August 10, 2006 contended that "while the applicant is arguing that the mechanism would be different, the claims simply require that there be present a lactone as described in the instant claims." *See Office action mailed August 10, 2006*, page 4, line 9-13. *See also Office action mailed August 10, 2006*, page 2, para. 2 (ignoring the subject matter recited in claim 21); Advisory Action mailed November 20, 2006.

Applicant respectfully disagrees. *Claim 21 is a method claim.* Method claims define their scope through the recitation of steps, such as the steps of a mechanism. In claim 21, the recited mechanism includes switching the solubility of the photoresist in a developer by exposing a lactone to an acid catalyst under vacuum, thereby causing the lactone to undergo a ring opening reaction upon exposure to the acid catalyst without molecules outgassing from the photoresist. Claim 21 thus does not simply require that a lactone be present. Rather, claim 21 requires the recited steps.

Since Yoon neither describes nor suggests subject matter recited in claim 21, claim 21 is not anticipated by Yoon. Indeed, the present rejection is facially deficient under 35 U.S.C. § 132 and 37 C.F.R. § 1.104(2) and fails to even contain a bald assertion that the recited subject matter is found in Yoon. Applicant therefore respectfully requests that the rejections of claim 21 and the claims dependent therefrom be withdrawn.

II. The rejection of independent claim 25 under 35 U.S.C § 102(e) as obvious over Yoon and Fednyshyn.

Claim 25 relates to a method that includes radiating an area of a chemically amplified photoresist in a vacuum environment to generate an acid within the photoresist, and catalyzing a ring-opening reaction in the photoresist. The ring-opening reaction suffices to switch the solubility of the photoresist in a developer without the generation of molecules that outgas from the photoresist in the vacuum environment.

As an obviousness rejection, the rejection of claim 25 is based on the contention that the recited subject matter would have been would be obvious to one of ordinary skill in light of Yoon and Fednyshyn. Applicant respectfully disagrees.

In this regard, as discussed above, Yoon's annular lactones that have a tertiary carbon are all understood to achieve solubility switching, at least in part, by cleaving side chains. Any ring-opening reaction undergone by Yoon's annular lactones that have a tertiary carbon does not appear to suffice to switch the solubility of the photoresist in a developer, as recited in claim 25.

Fednyshyn does nothing to remedy this deficiency in Yoon. Instead, Fednyshyn specifically identifies that outgassing can be reduced or eliminated without resorting to the use of ring-opening reactions to switch solubility. In this regard, Fednyshyn describes that aromatic compounds can be mixed with resin compositions to reduce outgassing. *See, e.g., Fednyshyn*, col. 2, line 10-13. Fednyshyn indicates that almost any resin composition "available to those of ordinary skill in the art" can be used. *See Fednyshyn*, col. 7, line 26-29. Fednyshyn also explicitly identifies that acrylate based polymers and methacrylate based polymers are "suitable examples." *See Fednyshyn*, col. 7, line 33-35.

As for aromatic compounds, Fednyshyn identifies that any of a large number of different suitable aromatic compounds will reduce or even eliminate outgassing. *See, e.g., Fednyshyn*, col. 5, line 52 - col. 6, line 21. Fednyshyn also makes it clear that whatever compound is chosen must be able to act as "radical scavengers or have the ability to form stabilizing (or stabilized) radicals." *See, e.g., Fednyshyn*, col. 4, line 66 - col. 5, line 2.

Thus, Fednyshyn describes that outgassing can be reduced or even avoided using aromatic compounds that scavenge or stabilize radicals. This has nothing to do with a ring-opening reaction suffices to switch the solubility of the photoresist. Indeed, Applicant submits that Fednyshyn's identification of an alternative mechanism to reducing or preventing outgassing would lead one of ordinary skill away from catalyzing a ring-opening reaction that suffices to switch the solubility of the photoresist in a developer without the generation of molecules that outgas from the photoresist in a vacuum environment, as recited in claim 25.

Like the rejection of claim 21, the rejection of claim 25 also ignores that *claim 25 is a method claim.* Once again, method claims define their scope through the recitation of steps, such as the steps of a mechanism. In claim 25, the recited mechanism includes catalyzing, in a photoresist, a ring-opening reaction that suffices to switch the solubility of the photoresist in a developer without the generation of molecules that outgas from the photoresist in a vacuum environment. Neither Yoon nor Fednyshyn would lead one of ordinary skill to these method steps.

When this was pointed out in the response filed May 30, 2006, the Office action mailed August 10, 2006 contended that

Fednyshyn is "cited [solely] for its teaching that styrenes are common co-monomers…"

Applicant respectfully submits that it is improper for the rejection to contend that some of Fednyshyn's teachings are relevant to the rejection while other of Fednyshyn's teachings are irrelevant and can be discarded. Instead, the examiner may not pick and chose from any one reference only so much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art. *See, e.g., Bausch & Lomb, Inc., v. Barnes-Hind/Hydrocurve Inc.*, 796 F.2d 443, 448 (Fed. Cir. 1986), *cert. denied*, 484 U.S. 823 (1987).

This is especially true in an obviousness rejection, where the motivations of one of ordinary skill are at issue to determine whether a suggestion to combine the references in the manner suggested is present. *See, e.g., In re Dow Chemical Co.*, 837 F.2d 469, 473 (Fed. Cir. 1988) (stating "[i]n determining whether such a suggestion can fairly be gleaned from the prior art, the *full field of the invention must be considered*; for the person of ordinary skill is charged with knowledge of the entire body of technological literature, including that which might lead away from the claimed invention.") (emphasis added).

In summary, not only do Fednyshyn and Yoon lead one of ordinary skill away from the claimed subject matter, even if Fednyshyn and Yoon were combined, one of ordinary skill would not arrive at the claimed subject matter. Claim 25 is therefore not obvious over Fednyshyn and Yoon. Applicant thus requests that the rejections of claim 25 and the claims dependent therefrom be withdrawn.

III. The rejection of independent claim 33 under 35 U.S.C. § 103(a) as obvious over Yoon and Fednyshyn.

Claim 33 relates to a photoresist that includes a polymer backbone, a lactone fused to the polymer backbone, the lactone comprising a tertiary carbon bonded to the lactone carbonyl oxygen, and a styrene ring side chain bonded to the polymer backbone. Sufficient lactone is fused to the polymer backbone so that a ring-opening reaction of the lactone to form an open ring structure suffices to switch a solubility of the photoresist in a developer.

As an obviousness rejection, the rejection of claim 33 is based on the contention that the recited subject matter would have been obvious to one of ordinary skill in light of Yoon and Fednyshyn. In particular, the rejection contends that it would have been obvious for one of ordinary skill to have added

Fednyshyn's aromatic compounds to Yoon's photoresists since "styrenes are common co-monomers with maelic anhydrides, acrylates, and methacrylates."

Applicant respectfully disagrees and instead submits that there is no reason to believe that it would have been obvious for one of ordinary skill to have added Fednyshyn's aromatic compounds to Yoon's photoresists. In this regard, as discussed above, Yoon's annular lactones that have a tertiary carbon are all understood to achieve the necessary solubility switching by cleaving side chains. *There is no reason to believe that Yoon's photoresists include sufficient lactone fused to the polymer backbone so that a ring-opening reaction of the lactone suffices to switch a solubility of the photoresist in a developer.* Indeed, the present rejection lacks even a bald contention that Yoon's photoresists include such a quantity of lactone.

Moreover, to the extent that the rejection is based on the contention that Yoon's annular lactones that have a tertiary carbon inherently include this quantity of lactone, Applicant submits that this contention is at odds with the obviousness rejection under 35 U.S.C. §103(a). In particular, Fednyshyn's aromatic compounds are added to his polymers for the purpose of stabilizing radicals to prevent them from outgassing. Even if Yoon's annular lactones that have a tertiary carbon were to include sufficient lactone fused to the polymer backbone so that a ring-opening reaction of the lactone suffices to switch a solubility of the photoresist in a developer (which applicant does not concede), there is no reason to add Fednyshyn's aromatic compounds. In particular, *there will be no need to stabilize radicals since, with the alleged sufficiency of lactone, the solubility of Yoon's annular lactones that have a tertiary carbon can be changed without excess generation of radicals that can outgas.*

In summary, the subject matter recited in claim 33 would not have been obvious tone of ordinary skill in light of Fednyshyn and Yoon. To begin with, Fednyshyn and Yoon neither describe nor suggest photoresists that include sufficient lactone fused to the polymer backbone so that a ring-opening reaction of the lactone suffices to switch a solubility of the photoresist in a developer, as recited in claim 33. Moreover, even if Yoon's photoresists did include such an amount of lactone, it would not have been obvious to one of ordinary skill to have added Fednyshyn's aromatic compounds since there would be no need to stabilize radicals.

Accordingly, claim 25 is not obvious over Fednyshyn and Yoon. Applicant requests that the rejections of claim 25 and the claims dependent therefrom be withdrawn.

IV. The rejection of independent claim 1 under 35 U.S.C. § 103(a) as obvious over Yoon and Fednyshyn.

Claim 1 relates to a photoresist. The photoresist includes a polymer backbone, a lactone bonded to the polymer backbone, and a side chain bonded to the polymer backbone. The lactone is reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure to switch a solubility of the photoresist in a developer without generating an organic species that can outgas in a vacuum environment. The side chain includes a styrene ring.

As an obviousness rejection, the rejection of claim 33 is based on the contention that the recited subject matter would have been obvious to one of ordinary skill in light of Yoon and Fednyshyn. In particular, the rejection contends that it would have been obvious for one of ordinary skill to have added Fednyshyn's aromatic compounds to Yoon's photoresists since "styrenes are common co-monomers with maelic anhydrides, acrylates, and methacrylates."

Applicant respectfully disagrees. In this regard, there is no reason to believe that Yoon inherently includes lactone that is reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure to switch a solubility of the photoresist in a developer without generating an organic species that can outgas in a vacuum environment. As discussed above, there is no reason to believe that the solubility of Yoon's photoresist can be switched by a ring-opening reaction to form an open ring structure, as recited in claim 1.

Moreover, if the solubility of Yoon's photoresist were taken to be switchable in this way for the sake of argument, this contention is inconsistent with the obviousness rejection under 35 U.S.C. §103(a). Fednyshyn's aromatic compounds are added to his polymers for the purpose of stabilizing radicals to prevent them from outgassing. To the extent that Yoon's lactone is reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure to switch a solubility of the photoresist in a developer without generating an organic species that can outgas in a vacuum environment (which applicant does not concede), there is no reason to add Fednyshyn's aromatic compounds to Yoon's polymer. In particular, there will be no need to stabilize radicals, since the solubility of Yoon's polymer can be changed without excess generation of radicals that can outgas.

Accordingly, even if Yoon's photoresists did include lactone that is reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure to switch a solubility of the photoresist in a developer without generating an organic species that can outgas in a vacuum environment, it would not have been obvious to one of ordinary skill to have combined Yoon with Fednyshyn to arrive at the recited subject matter.

Thus, claim 1 is not obvious over Fednyshyn and Yoon. Applicant requests that the rejections of claim 1 and the claims dependent therefrom be withdrawn.

Please apply the brief fee of $500 to Deposit Account No. 06-1050. Please apply any other charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

Date: January 29, 2007

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Appendix of Claims

1. A photoresist comprising:

a polymer backbone;

a lactone bonded to the polymer backbone, the lactone being reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure to switch a solubility of the photoresist in a developer without generating an organic species that can outgas in a vacuum environment; and

a side chain bonded to the polymer backbone, the side chain comprising a styrene ring.

2. The photoresist of Claim 1, wherein the lactone comprises a five-sided ring of carbon and oxygen.

3. The photoresist of Claim 1, wherein the lactone comprises a six-sided ring of carbon and oxygen.

4. The photoresist of Claim 1, further comprising a first group attached to the carbon bonded to the lactone carbonyl oxygen.

5. The photoresist of Claim 4, wherein the first group comprises an electron-withdrawing group.

6. The photoresist of Claim 4, wherein the first group comprises an alkyl group.

7. The photoresist of Claim 4, wherein the first group comprises a cage group.

8. The photoresist of Claim 4, wherein the first group comprises a phenyl group.

9. The photoresist of Claim 4, wherein the first group comprises carbon, oxygen and hydrogen.

10. The photoresist of Claim 4, wherein the first group comprises nitrogen dioxide.

11. The photoresist of Claim 4, wherein the first group comprises hydroxide.

12. The photoresist of Claim 4, wherein the first group comprises $-CF_3$.

13. The photoresist of Claim 4, further comprising a second group attached to the carbon bonded to the lactone carbonyl oxygen, the first and second groups comprising the same molecules.

14. The photoresist of Claim 4, further comprising a second group attached to the carbon bonded to the lactone

carbonyl oxygen, the first and second groups comprising different molecules.

15. The photoresist of Claim 1, further comprising a photoacid generator molecule to form the acid upon radiation exposure.

16. The photoresist of Claim 1, wherein the lactone is reactable in the presence of the acid to change a solubility of the photoresist in a basic aqueous developer.

17. The photoresist of Claim 1, wherein the lactone is reactable in the presence of the acid to form an open ring structure bound to the polymer backbone with no outgassing molecules in a vacuum environment.

18. The photoresist of Claim 17, wherein the open ring structure increases solubility of the photoresist in an aqueous base developer.

19. The photoresist of Claim 1, further comprising a side chain styrene group bonded to the polymer backbone.

20. The photoresist of Claim 19, wherein the side chain styrene group is attached to a group comprising at least one of hydroxide (OH), an alkyl group and a cage group.

21. A method comprising:

forming a photoresist having a polymer backbone and a lactone bonded to the polymer backbone; and

switching the solubility of the photoresist in a developer by exposing the lactone under vacuum, thereby causing the lactone to undergo a ring opening reaction upon exposure to an acid catalyst without molecules outgassing from the photoresist,

wherein the lactone includes a tertiary carbon bonded to the lactone carbonyl oxygen.

22. The method of Claim 21, wherein forming the photoresist comprises forming a chemically amplified photoresist.

23. The method of Claim 21, wherein forming the photoresist comprises forming the photoresist with a first group attached to the carbon bonded to the lactone carbonyl oxygen, the first group comprising one or more of an alkyl group, a cage group, and a phenyl group.

24. The method of Claim 21, wherein forming the photoresist comprises forming the photoresist with first and second groups attached to the carbon bonded to the lactone carbonyl oxygen, the first and second groups being identical.

25. A method comprising:

radiating an area of a chemically amplified photoresist in a vacuum environment to generate an acid within the photoresist; and

catalyzing a ring-opening reaction in the photoresist, the ring-opening reaction sufficing to switch the solubility of the photoresist in a developer without the generation of molecules that outgas from the photoresist in the vacuum environment.

26. The method of Claim 25, wherein said radiating comprises radiating with extreme ultraviolet (EUV) radiation.

27. The method of Claim 25, wherein said radiating comprises radiating the area of the photoresist comprising a hydroxystyrene copolymer.

28. The method of Claim 25, wherein generating the acid within the photoresist comprises catalyzing the ring-opening reaction of a lactone in the photoresist.

29. The method of Claim 28, wherein catalyzing the ring-opening reaction comprises catalyzing the ring-opening reaction of a lactone that includes a tertiary carbon bonded to the lactone carbonyl oxygen.

30. The photoresist of Claim 1, wherein the lactone comprises a tertiary carbon bonded to the lactone carbonyl oxygen.

31. The method of claim 21, wherein forming the photoresist comprises forming the polymer backbone using a hydroxystyrene copolymer.

32. The method of claim 21, wherein forming the photoresist comprises forming the lactone to undergo the ring opening reaction upon exposure to the acid catalyst and under semiconductor processing conditions.

33. A photoresist comprising:

a polymer backbone;

a lactone fused to the polymer backbone, the lactone comprising a tertiary carbon bonded to the lactone carbonyl oxygen; and

a styrene ring side chain bonded to the polymer backbone,

wherein sufficient lactone is fused to the polymer backbone so that a ring-opening reaction of the lactone to form an open ring structure suffices to switch a solubility of the photoresist in a developer.

34. A photoresist comprising:

a lactone bonded to a polymer backbone, the lactone being reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure without generating an organic species that can outgas in a vacuum environment, the lactone having a first group comprising nitrogen dioxide attached to the carbon bonded to the lactone carbonyl oxygen.

35. A photoresist comprising:

a lactone bonded to a polymer backbone, the lactone being reactable under semiconductor processing conditions and in the presence of an acid to undergo a ring-opening reaction and form an open ring structure without generating an organic species that can outgas in a vacuum environment, the lactone having a first group comprising $-CF_3$ attached to the carbon bonded to the lactone carbonyl oxygen.

Evidence Appendix

None.

Related Proceedings Appendix

None.